10/517757
DT05 Rec'd PCT/PTO 13 DEC 2004

Description

Rotation rate sensor with a vibrational gyroscope

The invention relates to a rotation rate sensor having a vibrational gyroscope which is part of at least one control loop which excites the vibrational gyroscope by supplying an excitation signal at its natural frequency, the vibrational gyroscope providing an output signal from which a noisy rotation rate signal is derived.

In rotation rate sensors having a vibrational gyroscope, the output signal which indicates the rotation rate and is caused by the Coriolis force is noisy, which adversely affects subsequent evaluation. It is an object of the invention to purge the rotation rate signal of noise as far as possible.

The invention achieves this object by virtue of the noisy rotation rate signal being supplied to inputs on a low pass filter with a controllable bandwidth and on a bandpass filter, and by virtue of the output of the bandpass filter being connected to a control input on the low pass filter via a threshold value circuit. The bandpass filter ensures that the threshold value circuit responds only to changes in the rotation rate signal. In addition, the noise component at the input of the threshold value circuit is reduced by the bandpass filter connected upstream.

In the case of the inventive rotation rate sensor, the noise in the case of a constant or slowly altered rotation rate signal is largely suppressed by the low pass filter. If the rotation rate signal is changing more quickly, however, the band limit of the low pass filter is increased, which means that the fast change is also passed on, with a corresponding noise component

being accepted in the short term.

Preferably, the inventive rotation rate sensor has provision for the threshold value circuit and the control input of the low pass filter to have a band selector arranged between them which follows a transition in the output signal from the threshold value circuit by producing a gradual transition in the signal which is supplied to the control input of the low pass filter. The transition time can be adjusted in both directions, i.e. from low band width for the low pass filter to high band width, and vice versa. This avoids interference in the rotation rate signal as a result of the low pass filter suddenly changing over.

In one advantageous requirement of the inventive rotation rate sensor, the bandpass filter lets through changes in the rotation rate signal which are faster than the changes let through by the low pass filter with a minimally set bandwidth and are at most as fast as the fastest changes caused by the rotation of the vibrational gyroscope. This ensures that the bandwidth of the low pass filter is increased when required, but that higher-frequency noise does not influence the control of the low pass filter.

So that the low pass filter is actuated appropriately both for positive and for negative changes in the rotation rate signal, another advantageous refinement provides for an output signal from the threshold value circuit to adopt a first level when the absolute value of the output signal from the bandpass filter is below a prescribed threshold, and also to adopt a second level.

The demands on the rotation rate sensor, for example the rotation rate measurement range or the signal-to-noise ratio, may vary from application to application.

Hence, in line with one development, the band limits of the bandpass filter and the threshold of the threshold value circuit are programmable. In this context, the limits of the adjustment range of the low pass filter and the transition time from the lowest to the highest limit and the transition time from the highest to the lowest bandwidth may also be programmable.

The invention permits numerous embodiments. One of these is shown schematically in the drawing by means of a plurality of figures and is described below. In the drawing:

Figure 1 shows a block diagram of a rotation rate sensor with a filter, and

Figure 2 shows a more detailed illustration of the filter.

Although the exemplary embodiment and parts thereof are shown as block diagrams, this does not mean that the inventive arrangement is limited to being implemented using individual circuits corresponding to the blocks. Rather, the inventive arrangement can be implemented particularly advantageously using large scale integrated circuits, e.g. digital signal processing. It is also possible to use microprocessors which, with suitable programming, perform the processing steps shown in the block diagrams.

Figure 1 shows a block diagram of an arrangement with a vibrational gyroscope 1 having two inputs 2, 3 for a primary excitation signal PD and a secondary excitation signal SD. The excitation is produced by suitable transducers, for example electromagnetic transducers. The vibrational gyroscope also has two outputs 4, 5 for a primary output signal PO and a secondary output signal SO. These signals forward the respective

vibration to physically offset points on the gyroscope. Such gyroscopes are known from EP 0 307 321 A1, for example, and are based on the effect of the Coriolis force.

The vibrational gyroscope 1 represents a high quality filter, with the section between the input 2 and the output 4 being part of a primary control loop 6 and the section between the input 3 and the output 5 being part of a secondary control loop 7. The primary control loop 6 is used to excite oscillations at the resonant frequency of the vibrational gyroscope, for example 14 kHz. In this case, the excitation is produced in an axis of the vibrational gyroscope with respect to which the direction of oscillation used for the secondary control loop is offset through 90°. In the secondary control loop 7, the signal SO is split into an inphase component and a quadrature component, one of which is supplied via a filter 8 to an output 9 from which a signal which is proportional to the rotation rate can be picked off.

In both control loops 6, 7, a fundamental part of the signal processing is performed digitally. The clock signals required for the signal processing are produced in a crystal-controlled digital frequency synthesizer 10 whose clock frequency is 14.5 MHz in the example shown. An explanation of further details is not given, since this is not necessary in order to understand the exemplary embodiment.

Figure 2 shows the filter 8 in a more detailed illustration. The rotation rate signal's path from an input 10 to the output 9 contains a controllable low pass filter 11. In addition, the noisy rotation rate signal is supplied to a bandpass filter 12 whose output is connected to a threshold value circuit 13 which compares the absolute value of the output signal from

the bandpass filter 12 with a threshold value S supplied at 14. The output of the threshold value circuit 13 is connected to a band selector 15 which controls the low pass filter 11 such that a transition in the output signal from the threshold value circuit 13 is followed by alteration of the cutoff frequency of the low pass filter 11 in a prescribed time. This time may be prescribed differently for different directions.

To improve understanding of the invention, Figure 2 schematically shows the amplitude/frequency responses of the low pass filter 11 and of the bandpass filter 12 and also the characteristic of the threshold value circuit 13. As already mentioned, the frequency ranges are dependent on respective applications, in the case of a motor vehicle application essentially on the noise component of rotation rate signal and on the mechanical inertia of the vehicle.